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SOIL MICROBIOLOGY AS A FIELD OF SCIENCE[1, 2]

By Dr. SELMAN A. WAKSMAN

NEW JERSEY AGRICULTURAL EXPERIMENT STATION, RUTGERS UNIVERSITY

THE question is frequently raised concerning the position occupied by soil microbiology in the field of knowledge, especially its relation to other biological sciences, on the one hand, and to agricultural sciences, notably soil science and crop science, on the other. In order to elaborate upon this relatively new branch of science, which is frequently only vaguely understood and often little appreciated, it is sufficient to define first the student of the subject, namely, the soil microbiologist.

[1] Journal Series Paper, New Jersey Agricultural Experiment Station, Rutgers University, Department of Microbiology.

[2] The writer has been called upon recently to define "soil microbiology" and to list a number of outstanding workers in this field of science. He has also been requested to differentiate the work of a microbiologist in relation to related sciences. If an excuse is needed to define a field of science, with which one has been concerned for more than three decades, this excuse is presented here.

WHAT IS A SOIL MICROBIOLOGIST?

A soil microbiologist, as the name implies, is a microbiologist who is concerned with soil microorganisms. His objective is to determine the nature of the microorganisms inhabiting the soil. He is concerned with the activities of these organisms and their characteristics of growth. He analyzes the interrelationships of the various elements of the microbial population of the soil, the reactions with which they are concerned, the influence of soil conditions on the microorganisms comprising the soil population, and the effects of the activities of the population on the soil and on the plants which develop in it. Finally,

he seeks means of bringing the resources of the soil population to the service of man.

In common with other microbiologists, the soil microbiologist is a biologist whose major interests center about the microscopic forms of life. He is also a biochemist, since he is concerned with the chemical reactions brought about by these microscopic living systems. He is interested in problems involving inorganic and physical chemistry: their importance is evident in the various reactions between inorganic compounds produced by microorganisms and soil materials, and the function of inorganic materials in the development of the microorganisms. He deals with soil structure, which is greatly affected by microbial development, and this as well as other effects of the soil microorganisms involves some consideration of physical chemistry. He deals with a special medium, the soil, in which these organisms live, not in pure culture but in the form of highly complex populations; these comprise many thousands of species, which exert upon one another a variety of associative and antagonistic effects. Because of these complex problems, the cooperative efforts of groups of workers bringing their special training to bear upon such problems is often required.

The soil microbiologist has, therefore, certain functions to perform which distinguish him, on the one hand, from other microbiologists and, on the other hand, from other soil investigators. His principal interest is often only in one of the fields listed below, but he has also a certain perspective recognition of the work of his fellows in other branches of the science, as well as in the related sciences of microbiology, plant physiology and biochemistry. The major fields or interests of a soil microbiologist may be briefly listed under the following categories:

(1) The microbiological population of the soil, including the bacteria, fungi, actinomycetes, protozoa, algae and other lower forms of plant and animal life: The soil microbiologist develops methods for the isolation and for the determination of the abundance and distribution of the various members of this population. These methods are quite distinct from corresponding methods employed by other microbiologists who study animal or plant diseases or those who are concerned with fermentations. Some of the microorganisms found in the soil are characteristic of this particular natural substrate, and occur very seldom, if at all, in other natural media. This is true of certain bacteria, such as the *Azotobacter* group and the nitrifying bacteria. These organisms may be found in other substrates, such as water basins and on dead plant and vegetable matter; they find in the soil a natural habitat. The relative abundance and the distribution of these organisms in the soil depend upon the nature of the soil, its treatment, the crop grown and a variety of other factors. Various groups of fungi, including some mucors and species of *Rhizopus*, *Trichoderma* and *Penicillium*, may be found in a variety of substrates, such as spoiled food or mildewed cloth, but it is in the soil that these species find their natural habitat and from which they are distributed by wind and water. The specific nature of these and of many other fungi, as well as their relative abundance in a soil depend entirely on the nature of the soil, its treatment and various environmental factors. Certain Basidiomycetes and Myxomycetes, for example, are characteristic of forest soils and of other soils rich in plant residues. The actinomycetes are represented in the soil by certain groups which are characteristic of the soil and are found only to a very limited extent in other substrates. The genus *Streptomyces*, for example, which comprises those forms that produce a well-developed aerial mycelium, is represented in the soil by hundreds of species, whereas the genus *Micromonospora* occurs largely in high temperature composts and in lake bottoms. Many other groups of microorganisms are found largely in the soil and only seldom elsewhere. The fact may thus be emphasized that the soil possesses a marked and characteristic microbiological population. Special methods are developed for the study of this population. Media are selected with a view to allowing the development of the greatest number of organisms in a limited space. Extensive use is made of enrichment methods and of selective culture methods, all of which have become essential tools in the hands of the soil microbiologist.

(2) The numerous interrelationships of the soil population, as well as the relations of these organisms to higher plants: These involve a variety of reactions, such as the struggle for development, the competition for nutrients, the favorable and unfavorable effects of one upon the other and the importance of these effects in determining the dominant populations of soil as compared with that of other natural environments. These phenomena also involve the part played by saprophytic soil microorganisms in the elimination of plant parasitic microorganisms. It involves the broad aspects of associative and antagonistic effects of microorganisms, the elucidation of which contributed materially to the development of our knowledge of the production of antibiotic substances. The relationships of microorganisms to higher plants comprise activities which are either adverse or favorable to plant growth; the latter comprise symbiosis of microorganisms with legumes and mycorrhiza formations. The complexity of the reactions taking place in the soil and the difficulty of obtaining a true perspective of the many processes

involved from simplified studies carried out under artificial conditions in the laboratory become self-evident.

(3) The decomposition of plant and animal residues on the surface of the soil as in composts, as well as in the soil itself and the formation of humus: When plants and animals die, or when the residues of their metabolic processes, either in the form of excreta or as dead tissues, find their way into the soil they become subject to attack by large numbers of microorganisms. The nature of these organisms and their relative abundance will depend largely upon the chemical composition of the materials undergoing decomposition, upon the rate of decomposition of the various specific chemical constituents of these materials and upon the environmental conditions, such as reaction of soil, moisture content, aeration and temperature. Among the chemical constituents, the most important are the simple carbohydrates, the starches, pectins and hemicelluloses, the true cellulose and lignin, the proteins and other nitrogenous compounds, the mineral elements, notably the phosphates, sulfates and various bases and their organic and inorganic forms. Some of these constituents, such as the simple carbohydrates and some of the proteins, are attacked very readily and by a great variety of organisms; large numbers of organisms are capable of decomposing cellulose, some of these organisms preferring this carbohydrate to other sources of carbon; some plant constituents, such as lignins and waxes, are attacked only slowly and by a few types of organisms. The rate of decomposition of the carbohydrates may depend to a large degree upon the presence and relative abundance of nitrogenous compounds. The fats, waxes, lignins and certain other compounds may gradually accumulate, because of their relative resistance to decomposition as compared to the other plant and animal constituents. Side by side with the decomposition processes the microorganisms synthesize considerable cell substance, the amount of synthesis being in many cases as much as 30 to 50 per cent. of the material destroyed. The resistant constituents of the plant residues together with the synthesized cell material gradually give rise to the organic matter of the soil commonly known as humus. This material is not of a homogeneous chemical nature, but it possesses certain properties which distinguish it clearly from other forms of organic matter. Its nature depends upon the composition of the material from which it has originated, the extent of its decomposition and the nature of the synthesized microbial cell substances. Although humus is fairly resistant to decomposition, it is subject to slow and gradual attack by a variety of microorganisms. This can be measured by the continuous stream of CO_2 given off during the decomposition process and by the liberation of the nitrogen as ammonia.

(4) The liberation, through the activities of microorganisms, of the nutrient elements essential for plant life in available forms; namely, the carbon as CO_2, the nitrogen as ammonia, the phosphorus as phosphate, the sulfur as sulfate, and others: Without these microbial activities, the limited supplies of these elements on the surface of the earth would soon become locked up in the form of plant and animal life, thus bringing to a standstill the development of new life. The varied activities of the soil-inhabiting microorganisms keep these elements in continuous circulation. These processes take place in a series of reactions many of which are brought about by different organisms with different physiological mechanisms. In studying these reactions the soil microbiologist thus contributes to a knowledge not only of soil processes but of microbial physiology as a whole. Let us take the cycle of nitrogen as an illustration. The transformation of the nitrogen in the protein to the amino acid stage, and later to the ammonia stage; the assimilation of the ammonia to build up microbial proteins; the oxidation of the ammonia to nitrate; the reduction of the latter to nitrite and to atmospheric nitrogen—all these involve a series of biochemical mechanisms, the elucidation of which has contributed materially to microbial physiology as a whole.

(5) Nitrogen-fixing bacteria and the mechanism of the fixation process: No other group of microorganisms and no other microbiological process are so characteristic of the soil as the reactions involving the fixation of gaseous nitrogen and its transformation into complex organic compounds. Although some of the bacteria capable of fixing nitrogen are found in other natural substrates, such as water basins, and some nitrogen may be fixed under these conditions, it is the soil which may be looked upon as the natural habitat of these organisms. The process of nitrogen-fixation contributes largely to the fertility of the soil and toward making it a medium favorable for extensive plant growth. Whether the leguminous plants harboring the root-nodule bacteria are growing in a wild state, whether they are cultivated in the form of special crops, or whether they are used in a given crop rotation for soil improvement purposes, the continuous, even if slow, increase in the supply of soil nitrogen resulting from the growth of such crops has long been recognized and advantage taken of it in developing systems of husbandry. The knowledge gained from the study of the mechanisms of the fixation process, although not fully elucidated as yet, has greatly contributed to the understanding of one of the

most significant biological reactions and of the physiology of a unique group of microorganisms.

(6) The process of nitrification: The soil microbiologist has largely initiated and has been chiefly responsible for the development of the knowledge gained on the autotrophic bacteria as a whole and the nitrifying forms in particular. Volumes have been written on the subject of nitrification, one of the most important processes in the soil and one of the most fascinating chapters in microbiology. The knowledge of the very peculiar physiologic characteristics of a group of bacteria, capable of utilizing the energy obtained by the oxidation of the ammonia to nitrite and of the latter to nitrate, has greatly enriched microbial physiology. These organisms may be present in other substrates, such as water basins and activated sewage disposal systems, but it is the soil that forms their natural habitat. Whether they have found their way from the soil into lakes and seas, and there is ample evidence for this, or whether they were first living in water basins before becoming established in the soil is a purely philosophical question. At present, they are universally present in soil, whereas in the sea they are largely found in areas close to land. There are but few cases on record of soils lacking in nitrifying bacteria. This may be due to excessive acidity or to anaerobic conditions, which either prevent the growth of these bacteria or inhibit the process of nitrate formation. The rate of accumulation of nitrate in the soil was found to correspond to the extent of microbiological activities in the soil as a whole and incidentally to soil fertility.

(7) Various other processes of oxidation and reduction brought about by soil microorganisms. Such processes may become, under certain special conditions, of great theoretical significance and practical importance. These include such reactions as the oxidation of sulfur to sulfuric acid and the oxidation of a variety of other inorganic and organic compounds; among the reduction processes, it is sufficient to mention the reduction of sulfate to hydrogen sulfide, of nitrate to nitrite, to ammonia or even to atmospheric nitrogen, and of various complex organic compounds. The organisms responsible for these processes may develop only when a combination of certain factors are favorable. Sulfate-reducing bacteria develop, for example, when conditions are anaerobic, when sulfate is present and when organic matter is provided. These reactions may either be important in themselves, as in the loss of nitrogen, or they may be responsible for secondary reactions, such as the corrosion of metals accompanying sulfate reduction.

(8) The role of microorganisms in the conservation of the soil: This important function has become recognized only recently. Through the cell material that is synthesized, especially the mycelial structures of fungi, and through the various products of cell metabolism, such as the slimy products of bacteria, microorganisms exert various physical and chemical effects upon the finer soil particles. This results in the aggregation of the particles and consequently in their rapid removal from the soil by flowing waters or strong winds. It is becoming more and more evident that one of the major problems in soil conservation is to supply a sufficient amount of organic matter and other nutrients to the microorganisms of the soil. These agents, through their processes of decomposition and synthesis, take a highly active part in binding the soil, thus preventing the breakdown of the soil structure through atmospheric agencies.

The soil microbiologist is thus found to deal with a highly complicated group of problems, which are primarily biological in nature but which have many chemical and physical phases and applications. Soil microbiology, like the older science of botany, has its ecological aspects, its physiological and biochemical problems and numerous practical applications. The applications bear, first of all, upon soil fertility and crop production. By reason of the diversity of the reactions which take place in the soil, it is necessary for the soil microbiologist to study and understand the physiology of various microorganisms. This is largely the reason why he has particular interest in and has made so many contributions to the field of microbial physiology.

There are also other phases and branches of microbiology to which the soil microbiologist has made important contributions. His field is thus not limited to the study of a few processes by simple methods, and the importance of soil microbiology is not restricted to a knowledge of practical crop production. With this in view, it becomes essential to recognize the relation of this science not only to other major sciences, but especially to those newer or special sciences with which it has had the greatest contact.

Soil Microbiology and Other Sciences

The soil microbiologist is thus shown to be in a position to make important contributions not only to the knowledge of the soil, plant nutrition, crop production or agronomy, and forestry, but also to several apparently distinct sciences. It is sufficient to mention, in this connection, the sciences of aerobiology, the biology and chemistry of fresh- and salt-water basins, the broad field of ecology and plant pathology, the problems of food preservation, of sanitation and of sewage purification, as well as the domain of public health and medicine. Brief outlines of some of these relations will suffice.

Most of the fungi and bacteria that one finds in the

air, no matter how far away from the land surface, have originated from the soil that has been carried by the wind in the form of dust particles. These organisms, having had their origin in the soil, behave in all respects like typical members of the soil population. This phenomenon not only has a bearing upon the problem of allergy but also upon a certain type of deep-seated infection that is often traced to certain soil-inhabiting microorganisms.

Any survey of the microbiological population of water basins, whether small land-locked or large oceans, will reveal certain facts that have an important bearing upon the close relationships between the nature of such populations and that commonly found in or characteristic of the soil. Bacteria, for example, are found in much greater abundance in those areas of the sea that are close to shore than in regions distant from land. The occasional presence in sea water close to shore of such typical soil organisms as specific fungi, actinomycetes and various bacteria, which are absent from or occur only rarely in waters far away from land, point to their soil origin. Certain special groups of bacteria, such as the nitrifying and aerobic nitrogen-fixing forms, that are found to occur with great regularity in waters close to land and are absent elsewhere in the sea, led to the question whether these organisms occur there only because they have been washed in from land or whether they are true sea-inhabiting organisms.

The science of ecology owes a great deal to our knowledge of soil-inhabiting microorganisms. One need only mention the effect of root-nodule bacteria on the growth of legumes, which influences, in turn, the growth of grasses and other plants; the effects of mycorrhiza fungi and certain other soil-inhabiting organisms upon forest vegetation and forest succession is another illustration.

Various investigators and technologists concerned with problems that are apparently totally unrelated to soil microbiological processes have come to the soil for an answer to their specific needs. Out of a number of illustrations that may be cited, it is sufficient to draw attention to the following three that recently have aroused great interest: (a) the subject of spoilage and deterioration of textiles, of leather goods, of wooden structures and of many other types of service materials, under conditions of high humidity and high temperature; (b) the search for microorganisms producing antibiotic substances; (c) the search for organisms concerned in various industrial fermentations.

The problem of "mildewing" of cotton cloth, of woolen material and of leather goods has recently received renewed emphasis because of the huge quantities of such materials that are being handled under moist and humid conditions. The various procedures used for preventing rapid deterioration of these materials brought out the fact that the fungi and bacteria that are responsible for the attack are largely of soil origin. The test organisms used in evaluating the resistance of such materials to "mildew" and to "rot" are typical soil forms. When a very severe type of test procedure is to be used, a soil suspension containing a number of different organisms is employed for inoculation purposes, or the material is actually buried in the soil for a given time under favorable conditions of moisture and temperature. These are not direct problems for the soil microbiologist, but much can be gained from a knowledge of the microbiological population of the soil and of the physiology of its constituent forms. This is true especially of the resistance of these organisms to poisons, their nutrient requirements, especially their ability to attack cellulose, the effects of relative humidity, etc.

The student of antibiotics and of their application to chemotherapy has long recognized the fact that some of the most important organisms that produce antibacterial substances find their permanent or temporary habitats in the soil. Thus, *Bacillus brevis* that produces tyrothricin is a typical soil bacterium; *Penicillium notatum* and *P. chrysogenum* that form penicillin are soil fungi; *Streptomyces lavendulae* and *S. griseus*, that give rise, under special conditions of culture, to streptothricin and streptomycin are soil actinomycetes. Investigators in numerous laboratories throughout the country are at this very moment enriching the soil with all sorts of pathogenic bacteria and other microorganisms, in order to stimulate the development of antagonistic forms that could be utilized for the production of desirable antibiotic substances. Literally thousands of fungi, bacteria and actinomycetes are now being isolated from soils or from composts, and tested for the production of such antibiotic agents. Here as well, a knowledge of the composition of the complex microbiological population of the soil and its variation under the influence of treatment would have saved a great waste of time and energy. Stories are told of aeroplanes collecting soil samples from all over the world, and of automobile trips throughout North America gathering bits of soil from which to isolate bacteria or fungi capable of producing specific antibiotic agents.

The contributions of the soil microbiologist to public health and to medicine has thus recently gained added significance. Knowledge already established by the soil microbiologist includes the disappearance in the soil of most of the pathogenic bacteria causing infections and epidemics in man and in animals, as contrasted to the survival of a few important bacterial pathogens, such as those containing tetanus and gas

gangrene and of a number of bacteria and fungi causing plant diseases. The relationship of the soil to a variety of other diseases, such as hookworm and deep-seated actinomycetic infections, is likewise a matter of great importance. Some of these problems require further elucidation.

One could cite other illustrations of contributions of soil microbiology to human welfare, perhaps not so spectacular as the above, but important nevertheless. The dependence of various industrial fermentations upon soil-inhabiting microorganisms is well known. Others include the anaeobic bacteria producing butyl alcohol and acetone, the butylene glycol organisms of both the aerobic and anaerobic types, and many other organisms that produce various organic acids and alcohols. The citric-, fumaric-, gluconic- and itaconic-acid-producing fungi are also largely soil-inhabiting organisms; the very name of the fungus producing the last acid has the flavor of the soil (*Aspergillus terreus*). The industrialist interested in fungi and bacteria producing pectolytic enzymes, as well as proteolytic and amylolytic enzymes, usually goes to the soil in search for appropriate organisms. Some of the vitamin-producing microorganisms are of soil origin.

Although in all the above cases, the soil and its extensive microbiological population were given but little consideration, much benefit could frequently have been derived from a knowledge of the environment in which these organisms live and of their mode of life in the soil.

What Should a Training in Soil Microbiology Be?

On the basis of the above facts one may feel justified in postulating the type of training a prospective worker in soil microbiology should acquire. Soil microbiology as well as its mother science, microbiology, is dependent on general bacteriology and on mycology, as well as on physiology and biochemistry. Soil microbiology does not comprise merely the study of legumes and their utilization, of *Azotobacter* and its physiology, or of the cycle of nitrogen in the soil, as glorified by the time-honored terms of "ammonification," "nitrification" and "denitrification"; it does not comprise merely the enumeration of bacteria and fungi in the soil, or the isolation and identification of so many hundreds of species of these organisms—it is all that and much more. Soil microbiology, like microbiology or bacteriology, has a much broader concept and has acquired many ramifications. These comprise specific aspects of ecology, taxonomy, physiology, biochemistry and practical utilization. The soil microbiologist carries a certain taxonomic responsibility, since it is highly essential to know the exact nature of the organisms involved in a given reaction or group of reactions, and not merely to list these organisms as bacteria, molds or protozoa. The student who devotes himself to soil microbiology is, therefore, entitled to learn the various phases of this relatively new science.

Summary

It can now be definitely recognized that the soil microbiologist is in a position to make important contributions not only to our knowledge of soil processes and plant growth, but also to microbiology, especially microbial physiology, and to the utilization of microorganisms for various industrial, public health and other processes. The soil microbiologist is able to contribute in many ways to man's capacity to survive, by learning to control the activities of injurious microorganisms and by favoring the processes brought about by the beneficial organisms.

The reason why the broader concept "microbiology" rather than the narrower term "bacteriology" has been used throughout this discussion is that the soil microbiologist has often to pay as much attention to the fungi as to the bacteria, and occasionally also to the protozoa, the algae and even the nematodes and other worms, inhabiting the soil in large numbers. Only a recognition of all these lower forms of life and their many interrelationships can help to elucidate this complex and important science.

OBITUARY

FRANCIS BERTODY SUMNER[1]

August 1, 1874–September 6, 1945

Professor Sumner's interests were primarily those of a naturalist; he is best known scientifically for his experimental studies on the nature and inheritance of adaptive variations as the key to an understanding of the problem of organic evolution. These studies have been widely recognized as being of exceptional significance. To him biology is also indebted for the first experimental proof of the origin by mutation of new varieties in any wild species of mammal and the Mendelian inheritance of their characteristics. At the time of his death he had been connected with the Scripps Institution for Biological Research (later the Scripps Institution of Oceanography) of the University of California for thirty-two years, having reached the retiring age of seventy the preceding

[1] Contributions from the Scripps Institution of Oceanography of the University of California, New Series No. 264.

ear. He is survived by his widow, two daughters nd a son.

Although he was born in Connecticut, his boyhood as spent first in Oakland, California, then in Colo- do Springs and later in Minneapolis. He gradu- ted from the University of Minnesota with the egree of B.S. at the age of twenty, in 1894. It was hrough his association with Minnesota's Professor Henry F. Nachtrieb that young Sumner was influ- nced to undertake zoology as a life career. His tudies were interrupted by ill health for a year, after which they were resumed in the Graduate School of Columbia University. Here he had the guidance of three of the country's leading zoologists, Professors Edmund B. Wilson, Henry F. Osborn and Bashford Dean, although he states in his autobiography that his work with Professor James McKeen Cattell was even more inspiring. In the summer of 1899 Sumner joined an expedition sent to the Egyptian Sudan under the auspices of Columbia University in the hope of securing material for a study of the embryology of the lungfish *Polypterus,* then purported to be a possible ancestor of land-living vertebrates. The expedition was unsuccessful, however, and one of the members died.

For two years previous to receiving the Ph.D. degree from Columbia, in 1901, Sumner taught an undergraduate course in "natural history" at the College of the City of New York. In lieu of the offer of any position elsewhere, this to him irksome job was continued for an additional three years. This experience convinced him that he did not have the aptitude for undergraduate teaching and he decided that his best chance for a successful career lay in some field of biological research. He found such an opportunity in connection with his duties as director of the U. S. Fish Commission laboratory at Woods Hole, 1903 to 1911. Here he began his studies on the relations of heredity and environment in mice. These studies, with some interruptions, constituted his chief problem for twenty-seven years. Other work at Woods Hole, by himself and several associates, consisted of an extensive biological survey of the adjacent seas and seacoasts. Then during the two years 1911 to 1913 he served as naturalist on the U.S.F.C. Steamer *Albatross* in a survey of the physical and biological conditions of San Francisco Bay.

The welcome opportunity of resuming his experimental studies on mice was then offered at the Scripps Institution. To these studies he devoted seventeen years (1913–1930) of intensive effort. This involved the collection of differently colored geographic races or subspecies of the genus Peromyscus at many localities—from the humid and semi-desert regions of the Pacific coast, the mountains and inland deserts, the alluvial valleys and extending to the white sandy shores of the Gulf of Mexico. These different types were then placed in adjacent compartments under identical environmental conditions at La Jolla. They and their progeny were bred for four to twelve generations. About 2,300 individuals were analyzed in the greatest detail. At the present time it should be needless to add that the progeny showed no heritable deviations as the result of their changed environment. From these stocks, however, Sumner succeeded in obtaining evidence which proved for the first time in any wild species of mammal that spontaneous mutations of large extent as well as minute variations in color patterns were transmitted as single or multiple Mendelian factors. The evidence clearly indicated that this was the mechanism responsible for the origin of geographic races and presumably for specific differentiation and evolution.

The results of these studies were published in six papers covering 280 pages, including one of 106 pages in the Bibliographia Genetica (vol. 9, 1932). This substantial support to the theory of organic evolution brought Sumner much distinction, as witnessed by his election to the National Academy of Sciences, the American Philosophical Society and the Philadelphia Academy of Sciences.

Sumner's second most important contribution to biological theory was his ingenious experiments substantiating the reality of adaptive coloration in the selective survival of individuals and hence, by inference, in evolution. His more recent studies include morphological and chemical analyses of the changes in the pigmentation of fishes subjected to different conditions of lighting. Numerous other papers on the embryology and physiology of fishes show the same meticulous care in devising and executing his experiments and in the strictly impartial analysis and evaluation of the results obtained. Such work will not have to be repeated.

It may be of interest to note that Sumner began his studies on heredity in mice in the expectation of finding evidence in support of the Lamarckian doctrine, only to become finally convinced by the results that such an hypothesis is untenable. In addition to his strictly biological reports he published a considerable number of papers dealing with various sociological, psychological and philosophical problems, including preservation of natural wild-life areas, in which he always took a lively interest. Only a short time before his death he had the satisfaction of seeing in print the last of his writings. Among these was his autobiography entitled "The Life History of an American Naturalist" and a philosophical discussion of old age and death.

In addition to the scientific societies already men-

tioned, Sumner was a member of many local and national societies devoted to the various subdivisions of biology. Personally he was a man of distinctly superior intellect, kindly and unostentatious on all occasions but fearlessly honest and always ready to champion the cause of the minority. Those who knew him will miss a friendly and always intellectually stimulating association.

WESLEY R. COE

RECENT DEATHS

DR. JOSEPH MCFARLAND, professor emeritus of pathology of the University of Pennsylvania, died on September 22 at the age of seventy-seven years.

ANNIE W. FLEMING, assistant professor of mathematics at Iowa State College, died on September 19. She had been a member of the department of mathematics since 1900.

FRANK W. GARRAN, dean of the Thayer School of Engineering of Dartmouth College, died on September 19 at the age of fifty-one years.

DR. SMITH ELY JELLIFFE, the neuropsychiatrist, died on September 25. He was seventy-eight years old.

CHARLES W. GILMORE, curator of vertebrate paleontology at the U. S. National Museum, died on September 27 at the age of seventy-one years.

EUGENE J. CARPENTER, of Portland, Ore., soil conservationist in the U. S. Soil Conservation Service, Pacific Coast Region, died on September 11.

E. LANCASTER-JONES, since 1938 keeper of the Science Museum Library, South Kensington, England, died on September 9 at the age of fifty-four years.

SCIENTIFIC EVENTS

JOINT HEARINGS IN THE CONGRESS ON SCIENCE BILLS

IN response to President Truman's message to Congress urging the early establishment of a single Federal Research Agency as one of the legislative measures needed for the future welfare and security of the nation, Senator Harley M. Kilgore (D., W. Va.), and Senator Warren G. Magnuson (D., Wash.), announced on September 25 that joint hearings on several science bills now before the Senate would begin on October 8. Because of the similarity of purpose and related character of the bills which have been referred to the Senate Military Affairs Committee and to the Senate Commerce Committee, Senators Kilgore, Magnuson and Pepper, heading subcommittees which are to consider S. 1297 (Kilgore-Johnson-Pepper), S. 1285 (Magnuson) and S. 1248 (Fulbright) have arranged joint hearings on these measures. Senator Pepper is in Europe and is expected to participate actively in these joint hearings upon his return.

All three bills provide for increased Government support of scientific research but have different detail as to the scope of research and methods of administration. The hearings are designed to summarize expert public opinion and to develop a legislative program with respect to Federal support for research for national security, a rising standard of public health and the general welfare.

Senators Kilgore and Magnuson stated:

> We are in full accord with the President's plea for early adoption of legislation to establish a central scientific agency of the government with sufficient funds to encourage and support scientific research for the national interest. In order to expedite such legislation we have agreed to hold joint hearings on the various science bills referred to our individual subcommittees.
>
> We also support wholeheartedly the President's decision that until such an agency can be established on a full operating basis, the Office of Scientific Research and Development and the Research Board for National Security should continue. There must be no gap between wartime and peacetime program of research if the Nation is to derive full profit in the future from what we have learned in the past.
>
> The atomic bomb has demonstrated, perhaps more vividly than any other single happening in history, the overwhelming importance of science in our national life. The same skill and scientific know-how which helped to bring rapid and decisive victory on the war fronts must now be used for the purpose of peace and national security. By continuing to promote the progress of science and the useful arts, as the Founding Fathers so wisely ordered, we shall be able to make large strides in improving our national health, in making secure our national defense, and in promoting prosperity and full employment.

In his message to the Congress, President Truman specifically called for a single Federal research agency which would perform the following functions:

1. Promote and support fundamental research and development projects in all matters pertaining to the defense and security of the Nation.
2. Promote and support research in the basic sciences and in the social sciences.
3. Promote and support research in medicine, public health and allied fields.
4. Provide financial assistance in the form of scholarships and grants for young men and women of proved scientific ability.
5. Coordinate and control diverse scientific activities

now conducted by the several departments and agencies of the Federal Government.

6. Make fully, freely and publicly available to commerce, industry, agriculture and academic institutions, the fruits of research financed by Federal funds.

The joint hearings are expected to continue three or possibly four weeks. Prominent scientists, heads of Government agencies concerned with research and development, representatives of industry and labor, educators and others will be invited to testify on the need for a national program of scientific research. Witnesses who have been invited to appear to testify in the first week of hearings include:

Dr. Isaiah Bowman, president, the Johns Hopkins University; Dr. James Conant, president, Harvard University; Professor Harlow Shapley, Harvard University; Eric Johnston, U. S. Chamber of Commerce; Ira Mosher, National Association of Manufacturers; William Green, American Federation of Labor; Philip Murray, Congress of Industrial Organizations; Edward O'Neal, Farm Bureau Federation; Charles Goss, National Grange; James G. Patton, National Farmers Union; Dr. Vannevar Bush, Office of Scientific Research and Development; Harold D. Smith, Bureau of the Budget; Robert P. Patterson, War Department; James V. Forrestal, Navy Department; Jerome C. Hunsaker, National Advisory Committee on Aeronautics; Henry A. Wallace, Department of Commerce, and Harold L. Ickes, Department of the Interior.

A list covering witnesses for the subsequent weeks is now in preparation. It is hoped that all those who wish to express themselves on this major legislation will forward statements to the Subcommittee on War Mobilization of the Senate Military Affairs Committee, or, if time permits, appear in personal testimony.

FELLOWSHIPS OFFERED BY THE EASTMAN KODAK COMPANY

To assist universities in reducing the postwar scarcity of young men with advanced technical training, the Eastman Kodak Company is expanding its grants of annual fellowships to aid graduate students of chemistry, physics, mechanical and electrical engineering and business administration. There will be twelve fellowships for doctoral work and ten fellowships for master's work. The previous Eastman Kodak grants were confined to the field of chemistry and chemical engineering and numbered only six. The fellowships carry no provision requiring the recipients subsequently to work for the company.

Of the awards to be granted persons pursuing doctoral training, one fellowship is designated for chemical engineering at the Massachusetts Institute of Technology; another is for work in organic chemistry at the University of Illinois; and another is for the study of physical chemistry at the University of Rochester under the direction of Professor W. A. Noyes, Jr. The nine other fellowships for doctoral work—six in chemistry and three in physics—will be rotated among various universities from year to year.

To encourage graduate training in the field of mechanical engineering, the Eastman Kodak Company is offering four fellowships to men majoring in design in work toward their master's degree. It is planned that two fellowships will be awarded, in addition, to students completing their master's degree in electrical engineering. These six fellowships are to be utilized at different universities each year. Four fellowships are being offered to young men doing graduate study in outstanding schools of business.

Selection of recipients for any of these fellowships will be the responsibility of the respective college or university where the fellowship is awarded for that particular college year. The only qualifications prescribed by the company are that the award shall be made on the basis of the recipient's demonstrated ability in his major field, his soundness of character, the faculty's confidence in him, his cooperativeness and his financial need.

THE JOHN SCOTT AWARD

JAMES SMITHSON was not the only early foreign benefactor of American science and technology. In 1816 a citizen of Edinburgh, Scotland, named John Scott, willed $4,000 in trust to the City of Philadelphia in order to provide "a copper medal and a premium of $20" to outstanding citizens who had promoted and contributed to the welfare of mankind. Why John Scott made this bequest to a city and country he had never visited is not entirely clear. It is supposed that his recognition of Philadelphia and Americans resulted from an earlier acquaintance with Benjamin Franklin. By the turn of the century the John Scott fund was worth $100,000, and in recent years each award carries an honorarium of $1,000.

Awards have been made from time to time by the Board of Directors of City Trusts, whose principal duty is to administer the funds of the estate of Stephen Girard. The recipients of the John Scott Award are chosen by the board upon recommendation of a scientific advisory committee. In the past the award has been made to such scientists and inventors as Sir Alexander Fleming, John C. Garand, Thomas A. Edison and Madame Curie.

On September 20, 1945, the John Scott Award was shared by a chemist, Dr. Lyle D. Goodhue, and an entomologist, Captain William N. Sullivan, Jr., Sn.C., for their discovery of the Freon-type of insecticidal

aerosol and their development of the aerosol bomb. Dr. Goodhue is senior chemist, Division of Insecticide Investigations, Bureau of Entomology and Plant Quarantine, Beltsville, Md.; Captain Sullivan is associate entomologist, Division of Control Investigations of the same bureau, on leave of absence for military service. Before the war Goodhue and Sullivan worked together at Beltsville, making a systematic study of methods of dispersing insecticides in air as a finely divided fog or smoke (aerosol) and of determining the relative effectiveness against insect pests of these dispersions. The writer witnessed Goodhue's conception of the idea of dissolving an insecticide in Freon or other volatile solvent that is a liquid in confinement and becomes a gas after issuing as a spray through a nozzle on a tank, or "bomb" as it was called later. As the liquid becomes a gas, which is harmless to man in the case of Freon, the material dissolved in it is dispersed in air as a residue of fog or smoke from the evaporating spray. In this manner, concentrated pyrethrum extract and DDT have been dispersed by the armed forces, chiefly for the control of malarial mosquitoes. More than thirty-five million aerosol bombs have been made for use by the Army and Navy. Now they are coming on the market for civilian use and will certainly make life more pleasant for those who live in mosquito-infested areas and more secure for those who may be exposed to anopheline mosquitoes. The aerosol bomb is the only benevolent bomb developed during the war.

The presentation of the award to Goodhue and Sullivan was preceded by a dinner for them and their guests given by the Board of City Trusts. At this gastronomic event the Bureau of Entomology and Plant Quarantine was represented by Dr. F. C. Bishopp, assistant chief in charge of research, and Dr. H. L. Haller, principal chemist of the Division of Insecticide Investigations. Mr. C. M. Smith, formerly in Insecticide Investigations, and Dr. F. L. Campbell, formerly in Control Investigations, were also present. The dinner was held on the second floor of the venerable building of the American Philosophical Society on Independence Square in Philadelphia. After dinner, in the meeting room below, Mr. Walter B. Gibbons, a member of the Board of City Trusts, addressed a small audience and presented to Dr. Goodhue and Captain Sullivan, individually, a scroll, a check for $500 and the John Scott Medal, "to the most deserving."

NEWS FROM ABROAD

PROFESSOR MARSTON TAYLOR BOGERT has received the following letter from the wife of the late Dr. Ernst Cohen, which corroborates and supplements the note from Dr. H. S. Van Klooster which appeared in the August 31 issue of SCIENCE:

I was just planning to write to you when your letter dated August 20 reached me and now there is the more reason to inform you of the tragic fate that befell my husband.

After having been arrested and put in a Dutch concentration camp for about four months in the course of 1943, the Gestapo authorities at the Hague released him from there and moreover absolved him from all anti-Jewish laws and regulations, thanks to his international reputation and to the services he paid to Germany after the last war.

Notwithstanding this, he was arrested again, without any plausible reason, on February 28, 1944, and transported to the notorious concentration camp at Auschwitz (Poland). After that I never heard from him again. The Gestapo at the Hague told me they regretted very much, but a subordinate official had made an error!

I asked the Swedish Embassy at Berlin for help as well as Professor Richard Kuhn at Heidelberg, but all in vain. My hope of seeing him back after the capitulation of Germany was soon frustrated and from information I got, I now must assume that he was killed by gas-poisoning soon after his arrival in Auschwitz, although any formal notice of his death never reached me.

How he would have given all his energy in helping you to revive the activities of the Union, for which he worked so many years with enthusiasm and zeal!

Dr. Bogert has also received a letter under date of September 13 from Dr. Einar Biilmann, professor of chemistry at the University of Copenhagen, president of the General Council of Danish Chemical Societies for International Cooperation and member of the Royal Academy of Sciences of Denmark.

In a session held to-day your letter of August 20 to the members of the Bureau of the International Union of Chemistry was submitted to our National Council of Chemistry.

I have the pleasure of informing you that the council unanimously authorized me as a member of the Bureau of the Union to continue cooperation with you in the endeavors to revive the activities of the Union.

I wish to express my congratulations to the successful termination of World War II and our thankfulness to the Allies for the liberation of this country from the German occupation.

Kenneth B. Raper, of the Northern Regional Research Laboratory, writes:

Dr. Johanna Westerdijk, directrice of the Centraalbureau voor Schimmelcultures, Baarn, Holland, has recently informed workers in this country that the large collection of microorganisms maintained by her and her associates there has survived the war in Europe without serious damage. Orders for cultures can again be addressed to her, and shipments to this and other allied countries will be made as soon as their postal service can accept parcels.

This news will be welcomed alike by mycologists, plant pathologists and microbiologists generally.

A letter received from Dr. Luigi Castaldi by Dr. Homer B. Latimer, of the University of Kansas, stated that he was well and was visiting in his home town of Florence. He has been able to continue his work except during the year of 1944 when, as he says, none of the Italian anatomists did any research. He has been at the University of Cagliari for the past seventeen years, but now that the fascist party is no longer in power he will become the director of the Anatomical Institute at Genoa. He has edited the "Scritti Biologici" since 1926. His address is Lungarno Archibusieri 4, Firenze, Italia.

Professor Dr. M. J. Sirks, Genetisch Instituut der Rijksuniversiteit Huis de Wolf, Haren (Groningen), Holland, has written the letter given below to Professor A. M. Banta, of Brown University.

One of our greatest difficulties in renewing our scientific life is the very great gap we have in our scientific knowledge by our isolation during the last five years. You could lend me a very valuable support by sending every reprint you have published since the spring of 1939 on genetics (including cytology, sexuality, human genetics, animal and plant breeding) and secondly by asking your colleagues to do the same.

SCIENTIFIC NOTES AND NEWS

THE Willard Gibbs Medal of the Chicago Section of the American Chemical Society was presented at a meeting of the section on the evening of September 29 to Dr. Frank C. Whitmore, dean of the School of Chemistry and Physics of Pennsylvania State College, in recognition of "outstanding contributions to organic chemistry, and vigorous leadership in organizations devoted to the advancement of chemistry." The presentation was made by Professor Carl S. Marvel, of the University of Illinois, president of the American Chemical Society.

DR. THEODORE P. WRIGHT, administrator of the Civil Aeronautics Administration, has been awarded the Daniel Guggenheim Medal for 1945 in recognition of his "outstanding contributions to the development of civil and military aircraft, and for notable achievement in assuring the success of our wartime production program."

THE honorary degree of doctor of science was conferred upon Dr. Henry S. Conard, professor emeritus of botany of Grinnell College, Iowa, at the commencement exercises of Haverford College, fifty years after he had received his master's degree from the same college.

DR. J. C. GEIGER, director of public health of the City and County of San Francisco, has been granted by the Dominican Republic the Supreme Decoration of the Order of Merit of Juan Pablo Duarte, grade of Knight Commander, with the following citation: "For distinguished service in public office as director of a noteworthy and alert Department of Health, and as a civic statesman in the field of foreign affairs."

SIR ALEXANDER FLEMING, the discoverer of penicillin, has been made a Commander of the Legion of Honor in Paris.

IT is reported in the press that Dr. B. A. Houssay, of the Instituto de Biología y Medicina, Experimental, Buenos Aires, has again been arrested by the Argentine Government.

DR. ROBERT L. SPENCER, professor of mechanical engineering and dean of the School of Engineering of the University of Delaware, has resigned because of ill health.

PROFESSOR ARTHUR M. BANTA, of the department of biology of Brown University, has at his request retired from teaching and is engaged in completing some papers for publication and in further research.

PROFESSOR WILLIAM ALLAN, chairman of the department of civil engineering of the College of the City of New York, has been appointed acting dean of the School of Technology, in the absence of Dean Albert B. Newman, who is in Germany as adviser in chemical engineering to the economic division of the United States Group Control Council.

PROMOTIONS and appointments in physics at Cornell University have been made as follows: Robert F. Bacher and Bruno Rossi have been advanced from the rank of associate professor to full professorships; Richard P. Feynman has been appointed assistant professor; Kenneth I. Greisen and Herbert F. Newhall have been advanced from the rank of instructor to assistant professorships.

DR. CARL TOLMAN has resigned from his position of section chief in the Minerals Division, Foreign Economic Administration, effective on September 27, to become professor of geology and head of the department at Washington University, St. Louis.

DR. JOHN V. SCUDI, formerly head of the Biochemical Research Laboratories of Merck and Company, Inc., Rahway, N. J., has been appointed assistant professor of pharmacology in the College of Physicians and Surgeons of Columbia University.

DR. LINDSAY S. OLIVE, of the Emergency Plant Disease Prevention Project at Beltsville, Maryland, has been appointed assistant professor of botany at the University of Georgia.

DR. G. H. BENHAM, assistant professor of agricultural chemistry at Macdonald College, McGill University, has been appointed associate professor of biochemistry at the Illinois Institute of Technology, Chicago.

DR. GEORGE W. FISCHER, pathologist with the United States Department of Agriculture, a former instructor in the department of plant pathology at the State College of Washington, has been appointed head of the department and chairman of the Division of Plant Pathology in the Agricultural Experiment Stations. He took up this work on September 15, succeeding Dr. E. J. Anderson, who resigned to return to his former position as plant pathologist with the Pineapple Research Institute of Hawaii.

A GRANT has been made by Sharp and Dohme, Inc., of Glenolden, Pa., to the department of bacteriology of the University of Tennessee, Knoxville, for a study of sulfa drugs in the control of fowl-typhoid infection. The investigation will be conducted by Dr. D. Frank Holtman, professor of bacteriology and head of the department.

DR. E. W. LINDSTROM, head of the department of genetics and vice-dean of the Graduate College of the Iowa State College, has recently returned from a year's work in Colombia, South America. He served as visiting professor in the Facultad Nacional de Agronomia, at Medellin. This was a cooperative project between the United States State Department and the National University of Colombia. Courses in genetics, plant breeding and applied statistics were given to the university students and to the government "agronomos" (experiment station workers) of Colombia. A new maize hybrid program was also inaugurated.

DR. JULIAN HUXLEY, F.R.S., lectured in Switzerland during September under the auspices of the British Council.

A PARTY of eight French agriculturists and farmers, headed by M. Raymond Braconnier, director of agricultural production, recently spent ten days in England as guests of the British Council. They visited the Cambridge School of Agriculture, the Rothamsted Experimental Station, the National Institute for Research in Dairying at Reading and the Windsor Estate.

A JOINT meeting of the National Academy of Sciences and the American Philosophical Society will be held in Philadelphia on November 16 and 17. A special committee appointed by the two organizations will have charge of the program arrangements.

THE American Society of Mechanical Engineers met at the Hotel Netherland-Plaza, Cincinnati, on Tuesday and Wednesday, October 2 and 3. A me morial session in honor of the late Dean Herma Schneider, of the University of Cincinnati, conclude a two-day program with a symposium on cooperativ education on Wednesday evening. There were twelv technical meetings, several of which were in sessio at the same time, starting at 9:45 on Tuesday morn ing. Dr. Raymond Walters, president of the Univer sity of Cincinnati, addressed the management sessio on Wednesday afternoon.

THE Institute of Radio Engineers will hold its an nual winter technical meeting at the Astor Hotel, Ne York, from January 23 to 26.

A SYMPOSIUM on "Industrial Radiography an X-Ray Diffraction" will be held at Marquette Univer sity, Milwaukee, on November 9 and 11. This sym posium will stress industrial and applied x-rays.

A FRIEND of the Harvard Apparatus Company Inc., of Dover, Mass., has made a gift of $5,694 t this company. The company is a non-profit organi zation, and its spare funds support the annual W. T Porter fellowship, administered by the council of th American Physiological Society.

APPLICATIONS can now be sent to the departmen of chemistry of the University of Pittsburgh for graduate research scholarship in biochemistry o $1,200 for the twelve-month year with remission o tuition and fees. The scholarship is supported b Standard Brands, Incorporated. United States an Canadian citizens are eligible.

FELLOWSHIPS are available now at the Betatron Laboratory of the Ohio State University for both pre-doctorate and post-doctorate experimental physi cists. The stipend will depend upon the individual's qualifications. Correspondence concerning these fel lowships should be addressed to the director, Betatron Laboratory, Ohio State University, Columbus 10, Ohio.

THE University of Chicago has established, as a part of the division of biological sciences at the uni versity, an institute for applying the results of re search in nuclear physics to such problems as can cer, heredity and the aging process. The institute will be under the direction of Professor Raymond E. Zirkle, who has specialized in the effect of radiations on living organisms. It will be known as the Institute of Radiobiology and Biophysics, and will study the improvement of techniques for the protection of workers using radioactive materials. Members of the institute will work in close cooperation with members of the Institute of Nuclear Studies, which is under the direction of Professor Samuel K. Allison, physi cist.

THE Massachusetts Institute of Technology has received gifts amounting to half a million dollars for the establishment of a gas turbine laboratory for graduate instruction and for research.

A GIFT of $100,000 to be used in the encouragement of fundamental research has been received by the Ohio State University from its Research Foundation. This sum, according to Dr. A. R. Olpin, secretary and executive director of the foundation, represents a return to the university for the use of its facilities in governmental and industrial research. It is taken from its research reserve, accumulated through earnings from patent licensing and other sources. It is expected that all or most of the appropriation will be used in the creation of fellowships at the university. To assist in the drafting of policies and procedures, President Howard L. Bevis will appoint a committee, including representatives of his office, the foundation, the graduate school, engineering, the physical sciences, the biological sciences and the social sciences.

NEW research laboratories, to be erected at a cost of more than $2,000,000 by the Winthrop Chemical Company, are planned. A sixty-acre site at Rensselaer, N. Y., has been purchased for that purpose. In addition to offices, the administrative wing will have space for a technical library of eighty thousand volumes. The biological wing will contain twenty-five laboratory units, together with rooms for photography, x-ray and extreme temperature testing. The wing for chemistry will have thirty-two laboratory units, as well as special chemical and development facilities and a pilot development plant. The company reports that three hundred and fifty investigators will be employed exclusively on research, as compared with the present one hundred and seventy-five.

THE trustees of *Biological Abstracts* announce the establishment, beginning in January, 1946, of a new section of *Biological Abstracts*—Section H, for Abstracts of Human Biology—intended for anthropologists, sociologists, psychologists, neurologists and psychiatrists, students of child development and human welfare and students of man generally. The new section will be an assemblage of all abstracts published in *Biological Abstracts* dealing with the broad field of human and social biology. Biological studies on human inheritance, on population and fertility, on endocrine and neurological factors affecting growth, development and human personality, on alcoholism and drug addiction, and on nervous disorders and mental deficiencies, and broad nutritional and epidemiological studies affecting human welfare, are some of the many fields that will be covered. Full information may be obtained by writing to H. I. Anderson, Business Manager, Biological Abstracts, University of Pennsylvania, Philadelphia 4, Pennsylvania.

THE fifth annual Science Talent Search among high-school seniors to discover the forty students with the greatest scientific promise will open this month, according to an announcement by Watson Davis, director of Science Clubs. Two four-year Westinghouse science grand scholarships of $2,400 each will be awarded, and eight four-year science scholarships of $400 each. An additional $3,000 may be distributed at the discretion of the judges.

THE third in the series of conferences between Britain, Canada and the United States during the past two years under the auspices of the Combined Production and Resources Board, on the unification of engineering standards, opened at Ottawa on September 24. The delegation is headed by Stanley J. Harley, technical controller of Machine Tool Control.

THROUGH a typographical error in the issue of SCIENCE of September 21, the name of the newly elected president of the American Psychological Association was given as Barrett instead of Garrett.

UNDER the alumni fund of Norwich University, Northfield, Vt., known at the military college as "Living Endowment," special contributions have been received to be used to pay the transportation expenses of faculty members attending meetings of their professional societies. Faculty members who elect to make trips to professional meetings will pay their own expenses at the time, but at the end of the fiscal year the fund will be divided among them according to a formula that has been devised to provide fair distribution of the money in the form of dividends.

IT is stated in the *Journal* of the American Medical Association that Dr. Albert C. Furstenberg, dean of the Medical School of the University of Michigan, has announced that there are ten one-year fellowships in psychiatry now available at the university. These fellowships, which offer an annual stipend of $2,000 and which are under the sponsorship of the Office of Veterans' Affairs of the State of Michigan, include training at the Neuropsychiatric Institute of the university. Candidates must be graduates of an approved medical school and must complete a rotating internship before beginning their fellowships. Applications should be made to Dr. Raymond W. Waggoner, professor of psychiatry, University Hospital, Ann Arbor.

LEDERLE LABORATORIES, a unit of the American Cyanamid Company, has renewed for the second year a grant of $1,500 to the School of Medicine of Western Reserve University in support of a fellow-

ship in the department of pharmacology. The fellowship will aid in training pharmacologists and in the conduct of research, both fundamental and applied.

THE Moore School of Electrical Engineering of the University of Pennsylvania will be enlarged at a cost of nearly $125,000. A contract awarded by the university calls for construction of a third floor which will add 13,000 square feet of laboratory space. The additional laboratory area will be adapted for research in various phases of electronics, such as television and industrial control, and will be used also for the investigation of problems related to electrical machinery.

SPECIAL ARTICLES

SUSCEPTIBILITY OF THE YOUNG WHITE MOUSE (MUS MUSCULUS) TO EXPERIMENTAL LEPTOSPIROSIS

IN 1941 Larson reported[1] that white mice (*Mus musculus*) about 3 weeks of age were uniformly susceptible to experimental infection with *Leptospira icterohemorrhagiae* by practically all routes of infection. Inoculation was followed by the development of icteric and hemorrhagic lesions typical of this infection and by death within two weeks. Subsequently, the same worker perfected a diagnostic protection test[2] for leptospirosis based on the extreme sensitivity of young white mice to infection. Inasmuch as the guinea pig, the diagnostic animal now used, is less susceptible and more expensive than mice, the advantages of the new test are obvious. It was therefore considered worthwhile, in the course of other studies on experimental leptospirosis, to determine whether our strain of white mouse is susceptible to this infection.

For this purpose three cultures of *Leptospira icterohemorrhagiae* on Verwoort-Schuffner medium, strains labeled 626, 1653 and WRZ, were obtained from Dr. Larson, at the National Institute of Health, Bethesda, Maryland. Each of these strains had been passed by Larson through many generations of white mice and had killed practically 100 per cent. of injected animals. The mice used in our studies were a strain of *Mus musculus* which had been cage-inbred for many years in the Department of Bacteriology at the University of Minnesota. Unfortunately, no records are available revealing the origin of this strain.

Immediately upon receipt, each strain of spirochete was inoculated intraperitoneally in 0.5 ml amounts into 2 young white mice about 3 weeks old. One milliliter of each culture was subcultured on several tubes of Schuffner medium. As soon as subcultures revealed a heavy growth of organisms upon dark-field examination, they were used as inoculum in experiments. In order to test the virulence of the cultures, animals known to be susceptible to leptospirosis were inoculated. One milliliter was injected intraperitoneally into 2 deer mice and 2 young guinea pigs, and 0.5 ml by the same route into a young Syrian hamster.

One milliliter doses of culture were injected intraperitoneally and subcutaneously into young white mice between 2 and 3 weeks old, and 0.03 ml doses were injected intracranially. These inocula and routes of infection were also used in mice that had been inoculated intraperitoneally with 0.25 ml of a mixture of equal parts of benzol and olive oil 36 hours earlier. A third group of young mice was injected by the same routes and with the same volumes of leptospirae suspended in equal volumes of mucin prepared by Siler's method.[3] Another group of young mice were inoculated intraperitoneally with 0.5 ml of spirochetal culture 24 hours after establishment of a sterile inflammatory focus in the brain of each animal by intracranial inoculation of 0.03 ml of 5.5 per cent. starch solution in nutrient broth. Unless otherwise indicated, 3 mice were inoculated with each dose and by each route.

Daily cultures were made from the heart's blood of all animals for 3 weeks following inoculation. The mice were observed carefully daily for signs of generalized jaundice or hemorrhage and hyperemia of the bulbar conjunctivae. One, two and three weeks after inoculation, one animal from each group of 3 was killed by asphyxiation with gas. Subcultures, inoculations and tissue sections were made from the kidneys, livers and lungs of all animals, and also from the brains of animals inoculated intracranially or intraperitoneally following intracranial administration of starch solution. The sections were stained with hematoxylin and eosin.

All the inoculated guinea pigs and deer mice and the hamster developed typical signs of leptospirosis and succumbed within 10 days after injection. On the other hand, none of the injected white mice exhibited signs of frank leptospirosis and, in fact, none appeared sick. However, most of the blood cultures made from infected white mice were positive for about a week after subcutaneous and intraperitoneal inoculation, but were negative following intracranial injection. Organisms were isolated by animal inoculation

[1] C. L. Larson, *Pub. Health Rep.*, 56: 1546, 1941.
[2] *Ibid.*, 56: 1593, 1941.
[3] J. F. Siler, "Immunization to Typhoid Fever." Baltimore: Johns Hopkins Press, 1941.

from the blood, kidneys and liver of many mice during the first week, but they were isolated only from the kidneys of some mice during the second and third weeks after injection. Mild congestion of the liver and occasional hemorrhages in the kidneys and lungs were observed in sections of mouse tissues. The brains were normal except for a mild, mononuclear meningitis in a few instances. Multiple petechial hemorrhages in the lungs were the most common lesions observed. In the few cases in which sera taken from the mice after injection were pooled and tested, the several lots agglutinated live and killed leptospirae in titers ranging from 1:10 a week after inoculation to 1:30,000 3 weeks after injection.

After unsuccessful attempts to produce frank leptospirosis in young white mice by the methods described, it was decided to use younger mice and larger doses of organisms in the hope of overwhelming an immunologically-immature host with great numbers of organisms. Accordingly, 5 mice several days old were inoculated intraperitoneally with 1.5 ml of a heavy suspension of strain 1,653. These mice were observed and examined exactly as were the more mature animals. The results of these studies were similar to the results of the studies on older individuals. None of the immature mice succumbed to the infection, although all of them eventually became carriers of the organism, harboring them in their kidneys. Examination of tissue sections disclosed that lesions the same as those seen in the older mice occurred more frequently in the younger individuals. Agglutination tests performed on 2 sera collected 3 weeks after injection yielded titers of 1:300 and 1:100 against the spirochete.

Discussion

In the present study, in which the same strains of spirochete used by Larson[1,2] were employed, our strain of young white mouse (*Mus musculus*) did not develop fatal leptospirosis. Although the animals that did become infected manifested some of the early pathological changes characteristic of leptospirosis and harbored the organisms in their kidneys, they did not succumb to the infection. Several methods used by other investigators either to enhance the virulence of the infective agent (suspension in mucin[4]), or to interfere with the defensive reactions of the host to infection (inoculations of benzol[5] and starch[6]) have failed to influence the course of experimental infection of the young white mouse with leptospirae. Inoculation of overwhelming doses of organism into immunologically-immature individuals was also without effect. Packchanian[7] has already shown that there are differences of varying degree in the susceptibility of different species of mice and rats to leptospirosis. A short while after these experiments were completed a paper by Das Gupta[8] appeared. This investigator did not use special methods to facilitate infection. He was unsuccessful in infecting a number of 3-week-old white mice (*Mus musculus*) with *Leptospira icterohemorrhagiae*. Control guinea pigs injected with the same cultures succumbed to typical and fatal infections.

The results of this study, combined with those of Larson on the susceptibility of his strain of *Mus musculus* to fatal infection, and the negative results of Das Gupta suggest that in addition to differences between species there are differences within species as to resistance to leptospirosis. A genetic difference between strains within a species has already been observed in mice with respect to resistance to mouse typhoid[9] and mammary carcinoma.[10] The mechanism or basis of the genetic differences in resistance to leptospirosis has not been fully elucidated. However, other studies by one of us[11] suggest that the humoral rather than the cellular defensive reactions of the host are the important factor involved. It is possible that subsequent studies may show a significantly greater rate of production of lytic antibodies in resistant strains of white mice than is found in more susceptible strains.

Summary

The failure of even special methods to induce infection indicates that not all strains of young white laboratory mice (*Mus musculus*) are uniformly susceptible to fatal infection with *Leptospira icterohemorrhagiae*. Some strains of this species develop early pathological changes characteristic of the infection and harbor the organism in their kidneys, but do not succumb. Therefore not all strains of white mice are suitable for use in the diagnostic mouse protection test for leptospirosis described by Larson.[2]

ABRAM B. STAVITSKY
ROBERT G. GREEN
DEPARTMENT OF BACTERIOLOGY AND IMMUNOLOGY,
MEDICAL SCHOOL,
UNIVERSITY OF MINNESOTA

[4] W. J. Nungester, L. F. Jourdonais and A. A. Wolf, *Jour. Inf. Dis.*, 59: 11, 1936.
[5] A. R. Rich and C. M. McKee, *Johns Hopkins Hosp. Bull.*, 54: 277, 1934.
[6] W. L. Sawyer and W. Lloyd, *Jour. Exp. Med.*, 54: 533, 1931.
[7] A. Packchanian, *Pub. Health Rep.*, 55: 1389, 1940.
[8] B. M. Das Gupta, *Ind. Med. Gaz.*, 77: 284, 1942.
[9] J. W. Gowen and M. L. Calhoun, *Jour. Inf. Dis.*, 73: 40, 1943.
[10] J. J. Bittner, *Cancer Research*, 1: 793, 1941.
[11] A. B. Stavitsky, *Jour. Exp. Med.*, manuscript in progress.

IDENTIFICATION OF THE INHIBITORY FACTOR OF RETICULO-ENDOTHELIAL IMMUNE SERUM (REIS) IN A GLOBULIN FRACTION[1]

SUCCESSFUL demonstration of the inhibitory properties of strong concentrations of reticulo-endothelial immune serum (REIS) by *in vitro* (Pomerat and Anigstein[2]) and *in vivo* methods (Anigstein and Pomerat[3]) as well as evidence for its stimulating action at high dilution (Pomerat[4]) have initiated a search for the active principle involved. Isolation of albumin and globulin fractions of REIS have been carried out according to the following procedure.

To 5.0 ml of serum was added, with constant stirring, an equal volume of saturated ammonium sulfate. The suspension was allowed to stand for one hour at 37°, following which the precipitate was separated by centrifugation. The supernatant albumin fraction was removed with a capillary pipette, placed in a Cellophane bag (10 mm diameter Cellophane tubing was found to be satisfactory) and dialyzed against cold Tyrode's solution until the external fluid was sulfate-free. The albumin solution was then passed through a micro-Seitz filter and tested for its REIS effect.

In our first experiments, the precipitated globulins were redissolved in 5 per cent. saline and dialyzed against distilled water until free of chlorides. This procedure apparently resulted in some denaturation, since the precipitated globulins were no longer completely soluble in dilute salt solutions. The procedure finally adopted was to redissolve the precipitate from the original ammonium sulfate treatment in cold Tyrode and then to dialyze the solution against Tyrode for the same length of time as used in the treatment of the albumin fraction. The solution remained completely clear. Sterilization and testing of the globulin fraction were accomplished in the same manner as described for the albumin solution.

REIS fractions were added at various concentrations to tissue culture media in which heart fragments from chicks incubated for 6 days were grown. In some experiments the spleen of 18-day incubated chicks was used. Twelve per cent. embryonic extract and 50 per cent. heparinized rooster plasma served as the basic medium. Several preparations were used for each concentration tested.

Preliminary experiments demonstrated that traces of ammonium sulfate could be detected by the presence of aqueous vacuolization in migrating cells within a few hours of incubation. Tests with ammonium sulfate at 1:800 showed almost complete inhibition. In subsequent fractions, no trace of ammonium sulfate could be detected.

The albumin fraction obtained from homologous (anti-chick) REIS with a complement fixation titer of 1:1200 showed no inhibition of outgrowth from fibroblasts or from splenic fragments.

The globulin fraction, on the other hand, inhibited the outgrowth of fibroblasts and produced clumping of splenic cells to approximately the same degree as controls containing an equal dilution of corresponding REIS.

Globulin fractions of heterologous (anti-rat) REIS with a complement fixation titer of 1:1600 did not produce such inhibitory effects on chick tissues *in vitro*.

Experiments in progress will attempt to develop a method of measuring the potency of globulin fractions of REIS both as to their inhibitory and their possible stimulating action. Further fractionation of the globulins is also under study.

EDWARD H. FRIEDEN
C. M. POMERAT
LUDWIK ANIGSTEIN

[1] From the Departments of Dermatology and Syphilology, Anatomy, and Preventive Medicine and Public Health, The University of Texas School of Medicine, Galveston, Texas.

[2] Pomerat, C.M., and Anigstein, Ludwik, Texas Rep. on Biol. and Med., 3: 1, 122, 1945.

[3] Anigstein, Ludwik, and Pomerat, C.M., Fed. Proc., 4: 1, 111, 1945.

[4] Pomerat, C.M., Fed. Proc., 4: 1, 56, 1945.

THE EFFECT OF SODIUM CHLORIDE BALANCE ON THE AVIDITY OF ISOHEMAGGLUTININS

FACTORS having to do with the relationship of the titre of typing serums used for the determinations of the human blood groups are of importance.

Our own experience has shown, as also stated by others[1,2,3,4] that the agglutinin titres of human serums range from 1–1 to 1–2,048. This is without benefit of concentration or globulin fractionation of the original serum.

However, the individual whose serum shows an extremely high titre is rather rare and scarcely to be depended upon when attempting to prepare human anti-A and anti-B serums. To substantiate this, we have found upon testing the sera of approximately 52,000 bleedings received from the American Red Cross Blood Donor Service from which dried plasma was processed for the Army Medical Corps, that ten per cent. of these bloods show agglutinin activity so

[1] A. S. Wiener, "Blood Groups and Transfusion," Charles C Thomas Publishing Company, Springfield, Illinois, 3rd ed., 1943.

[2] L. Pillemer, J. L. Oneley, M. Melin, J. Elliott and M. D. Hutchinson, *Jour. Clin. Invest.*, Vol. xxiii, No. 4, p. 550.

[3] W. Thalhimer and S. A. Myron, *Jour. Am. Med. Ass.*, 118: 370, 1912.

[4] E. L. DeGowin, *Jour. Clin. Invest.*, 23: 554, 1944.

that when their sera are pooled after extremely careful selectivity the pool titre is 1–2,048. The selectivity includes three separate tests for activity as well as tests for specificity. In the careful preparation of these serum pools, we know that not every one of the sera used has an agglutinin titre of 1–2,048 individually. In this particular phase of the determination of the strength of the pool the specific cells used were a number of known weak group B and known A_2 subgroup.

Despite this apparently satisfactory titre it has been noted numerous times that the avidity of agglutinins does not always occur in direct relation to the number of agglutinins present in the human serum. Although the titre may show 1–2,048, the serum upon test against specific cells may result only in a moderate agglutination.

During the course of our recent investigations, we found it feasible to dry *in vacuo,* after preliminary deep freeze in dry ice, our pools of anti-A and anti-B serums. These were dried in 0.1 cc quantities, in small vials using a short drying period. We found that upon restoration with either a 1 per cent. or 5 per cent. cell suspension in 0.9 per cent. saline that the avidity of the agglutinins was more than doubled. The reaction equalled that of a serum highly concentrated by drying or a highly concentrated globulin fraction.

Inasmuch as only water is removed during the drying process, it was concluded that the alteration of the sodium chloride content was radically affecting the agglutinin strength. This was shown definitely when upon the addition of distilled water on restoration the activity of the serum was about the same as before drying, *i.e.,* moderate only. The same effect was obtained where solid HaCl was added to liquid serum in order to increase toxicity.

Tests were set up to determine the amount of sodium chloride in cell suspensions which, added to the dry serums, would impart the greatest avidity to the agglutinins. Using 5 per cent. cell suspensions prepared in 0.5 per cent. sodium chloride, 0.6 per cent., 0.7 per cent., 0.75 per cent., 0.8 per cent., 0.85 per cent. and 0.9 per cent. both anti-A and anti-B showed complete agglutination in two seconds and 4+ agglutination at 30 seconds. However, upon varying the amount of sodium chloride from 1.1 per cent. to 2.0 per cent. (by tenth per cents.) in cell suspensions, we noted a gradual lessening of avidity. At 2.0 per cent. the reaction was almost doubtful.

Therefore, at the present time we find that a final salt concentration in a range of 1.45 per cent. to 1.75 per cent. will impart the greatest avidity to the isohemagglutinins.

SUMMARY

(1) The avidity of agglutinins in human anti-A and anti-B serums is influenced by the tonicity of the menstruum.

(2) The addition of sodium chloride in final concentration in a range of 1.45 to 1.75 per cent. will greatly increase the avidity of human serum isohemagglutinins.

The author wishes to gratefully acknowledge the suggestion of Captain John Elliott (U.S.A.Sn.C.), that the restoration with hypertonic saline solution be investigated.

KATHARINE O. PATTERSON
WYETH INSTITUTE OF APPLIED BIOCHEMISTRY,
PHILADELPHIA, PA.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

CONTROL AND EVALUATION OF BLOOD SERUM ASSAYS FOR PENICILLIN

THE power of the blood of man and animals to inhibit the growth of many bacteria has long been recognized. This inhibitory power varies with species and races, but it manifests itself primarily as an individual difference either in immunity or possibly in metabolism or body chemistry. Blood of normal adults is more inhibitory than that of normal children; disease increases the titre in both. Included among the organisms inhibited by the blood of man are streptococci, staphylococci and certain aerobic spore formers, all of which are employed at present in the assay for the potency of penicillin.

For the past year[1] a serial dilution method of assay employing *Bacillus subtilis* as the test organism has been used. In investigational work on several salts of penicillin,[2] oral penicillin[3] and penicillin "X",[4] several hundred blood samples obtained at varying intervals after the administration of penicillin were assayed. A blood specimen taken from an individual prior to administration of penicillin served as a control. After a number of individuals (laboratory personnel) had volunteered as test subjects several times each, it was observed that the titre of the blood-inhibitory substances for *B. subtilis* was both variable and transitory in a given individual. It was obvious,

[1] Wm. A. Randall, C. W. Price and Henry Welch, SCIENCE, 101: 365, 1945.

[2] L. E. Putnam, H. Welch and S. Olansky, *Jour. Am. Med. Asn.*, 127: 204, 1945.

[3] H. Welch, C. W. Price and V. L. Chandler, *Jour. Am. Med. Asn.*, 128: 845, 1945.

[4] H. Welch, L. E. Putnam, Wm. A. Randall and R. P. Herwick, *Jour. Am. Med. Asn.*, 126: 1024, 1944.

therefore, that the titre of these inhibitory substances could materially affect the interpretation of the penicillin concentration of the blood sample. This would be true particularly when penicillin was present in the serum in concentrations of 0.125 unit or less. Estimation of blood penicillin levels is important in individuals undergoing treatment with the drug, and since infected persons usually give a higher titre of blood inhibitory substances than they would normally, differentiation is essential.

Addition of a penicillin inactivating substance to a duplicate dilution of the test serum, as a means of measuring the blood anti-subtilis inhibitory substances in each specimen assayed by our method, was investigated and proved satisfactory. Because of the comparatively low concentrations of penicillin present in the blood, only small quantities of the inactivating substance are required and the dilution of the serum tested is unaffected. The control series consists of a duplicate serial dilution of each serum under test by the *B. subtilis* method,[1] prepared as follows:

One-half ml amounts of broth are placed in Wassermann tubes and serial dilution by halves made by adding one-half ml of the serum being tested to one of the tubes and carrying one-half ml in serial dilution for as many tubes as necessary. The first tube in the series contains one-half ml of the serum only. To each tube is added 1.5 ml of broth containing a 1:100 dilution of a broth culture of *B. subtilis* plus the amount of sterile penicillin-inactivator necessary to destroy all the penicillin in the specimen. The standard solution (Calcium Salt reference standard) is similarly controlled and growth should occur in all tubes of this series.

We have employed two penicillin-inactivating substances in our investigation (commercial preparations of "Clarase"[5] and "Penicillinase"[6]), and have found them equally effective. The efficacy of each lot of either of these substances is established against a standard penicillin before use in the test. Since the penicillin is inactivated in the duplicate control series of each specimen, lack of growth of the organism in one or more tubes reveals the titre of the blood-inhibitory substances. If the inhibition titres of the penicillin assay series and the control series are equal, the serum under test is considered to have no penicillin activity. However, if the assay series shows one or more tubes of inhibition beyond that of the control series, it is recorded as the penicillin concentration of the serum.

In a series of 211 blood specimens collected at different intervals from 48 adults, assayed and controlled by this method, 85, or 40 per cent., have been shown to contain an anti-subtilis factor. Sixty-four of these showed inhibition, after complete inactivation of the penicillin present, in a 1:4 dilution, 15 in a 1:8, 5 in a 1:16 and one showed inhibition in a 1:32 dilution. In 16 (approximately 20 per cent.) of the 85 specimens showing anti-subtilis inhibitory substances, the titre was equal to that obtained in the test series, thus making it impossible to estimate the level of penicillin in these sera. These represented low levels of apparent penicillin concentration in the serum (less than 0.125 u/ml), and in the majority of cases were specimens collected 8 hours or more after administration of the drug. Four of the individuals were in good health (*i.e.*, not under treatment for a specific disease); the majority of the others were under treatment for gonorrhea. Of the four healthy individuals, only one showed blood inhibitory substances (titre 1:16), however, only one blood specimen was obtained from each of these persons. Of the 44 patients under treatment for specific disease, specimens from 24 (55 per cent.) contained an anti-subtilis factor.

The possibility that the anti-subtilis factors, particularly in higher titre, may have been due to the presence in the serum of types of penicillin other than "G" and "X" led us to test all available forms for inactivation by "Clarase." This was accomplished by employing 50 u/ml solutions of the following types of penicillin: crystalline "G", crystalline "X", crystalline "F" (2 lots), calcium reference standard and commercial sodium penicillin "X" (2 lots) in serial dilution, as described above, with a "Clarase" solution in the inoculum. The inactivation by "Clarase" of the seven different solutions was of the same order of magnitude. A chemical method of assay of penicillin employing the "penicillinase" indicated similarly complete inactivation of three types of penicillin ("G", "F" and "X") by that substance.

The addition to the blood specimen of a substance which neutralizes the effect of the blood-inhibitory power without interference with penicillin, thus eliminating the duplicate dilution of each serum is under investigation.

SUMMARY

A method for adequate control and evaluation of blood serum assays for penicillin is given and the effectiveness of the method for controlling the several types of penicillin is shown.

VELMA L. CHANDLER
CLIFFORD W. PRICE
WILLIAM A. RANDALL

FOOD AND DRUG ADMINISTRATION,
WASHINGTON, D. C.

[5] C. A. Lawrence, SCIENCE, 98: 413, 1943.
[6] E. B. McQuarrie and A. J. Liebmann, *Archives of Biochemistry*, 5: 307, 1944.

DISCUSSION

SOVIET BIOLOGY

SCIENCE has published recently two articles on Soviet biology. The article by Professor L. C. Dunn (1944, 99: 65–67) gave, in the main, a correct impression of the position held by Soviet biology in world science and of the innovations in the development of science brought about by the new social structure of the U.S.S.R. The general tone of Professor Dunn's article shows his profound understanding of the real nature of the new Russia and his desire to further friendly relations between the scientists and the governments of our two countries.

Professor Sax in his reply to Professor Dunn (1944, 99: 298–299) gives an incorrect estimate of the general position of biology in the U.S.S.R. He raises a number of political questions and maintains that Soviet political philosophy suppresses science in the U.S.S.R. and that biology is not free to develop. His statements are based entirely on what he believes to be the present position of his own branch of science, genetics, in the U.S.S.R.

He and other American geneticists may be pleased to know that his beliefs reflect a misunderstanding of the true facts, and that actually the science of genetics is making progress in the Soviet Union. A number of important genetics laboratories are doing good work: the laboratory of the former Institute of Experimental Biology, now the Academy of Sciences Institute of Cytology (directed by Professor Dubinin); the laboratory of plant genetics at the Timiriazev Agricultural Academy (directed by the present writer); the laboratory of genetics at Moscow University (directed by Professor Serebrovsky); the laboratory of fish genetics (directed by Professor Romashev); the laboratory of genetics at the Gorky University (directed by Professor Chetverikov[1]); the laboratory of plant selection at the Timiriazev Agricultural Academy (directed by Academician Lisitsin); the laboratory of genetics of the Ukrainian Academy (directed by Professor Gershenson); the laboratory of genetics at Voronezh University (directed by Professor Petrov), and a number of others.

At the Genetics conference held in Moscow University (December 12–19, 1944) the achievements and future tasks of Soviet and world genetics were discussed by a large gathering of scientists. A few of the papers read were those of Professor Dubinin on "Basic Problems in Genetics," Academician Serebrovsky on "Modern Trends in Genetics" and the present writer on "Problems of Polyploidy."

[1] Tschetverikoff.

Important results have been achieved in the field of polyploidy, and many new plant forms have been developed. This research is little known abroad, although some of my work on the development of new varieties of wheat has been mentioned in SCIENCE and *Nature*. Sakharov and Lutkov have developed new varieties of buckwheat; Navashin—kok-sagyz (the Russian dandelion, as it is called in America); Lutkov—flax; Rybin—hemp, etc. The work of these scholars offers splendid prospects for the future selection of the crops concerned. Those familiar with the earlier literature of Russian genetics will recognize most of the names listed above as those of scientists who were making outstanding contributions long before the beginning of the controversy about which Sax speaks so strongly. Their present position is in itself evidence that the careers of many Soviet geneticists have not been adversely affected by the above-mentioned controversy. There have also been some noteworthy achievements in the investigation of the delicate structures and the changeability of chromosomes, the intracellular factors in heredity. Professor M. Navashin, whom Dr. Sax specifically mentions among those from whom he hears nothing scientifically, has published four articles since 1939, and in 1944 handed in two more for publication. These papers represent a continuation of the excellent work in cytogenetics for which he has for some time been highly esteemed in both the United States and the U.S.S.R. They in no way indicate that he has been forced to curtail or modify adversely his scientific work because of political pressure.

Unfortunately Professor Sax seems to be ignorant of this work, since he regards present-day Soviet biology and particularly genetics as synonymous with the name of Academician Lysenko. He criticizes Lysenko's mistaken views and appears to be of the opinion that he is not only criticizing Academician Lysenko but also the very foundation of Soviet biology, and the Soviet Government's attitude toward science.

This grave misunderstanding may have arisen partly through the impaired communications between the United States and the Soviet Union in recent years, so that he has not been able to see the papers resulting from the work mentioned above. The actual situation is as follows.

As an agronomist, Academician Lysenko has put forward a number of practical suggestions which have been of great value to the Soviet Government. Many Soviet geneticists are, however, sharply critical of his theories about genetics, and in no way support his at-

tempt to re-examine and discard a number of the fundamental postulates of our science.

The Soviet Government has never interfered in the discussions of genetic questions which have now been raging for some ten years. Academician Lysenko was rewarded for his work in the field of practical scientific farming and not for his views or experiments on genetics. Furthermore a number of our geneticists and plant breeders—some of whom have developed new varieties of the chief grain crops (Konstantinov, Lisitsin, Shekhurdin, Yuriev, the present writer and several others) and who have sharply criticized Academician Lysenko's views on genetics and selection—have also been decorated by the Soviet Government.

These facts should serve to show that Academician Lysenko's criticism of genetics, based as it is on naive and purely speculative conclusions, despite the vigor of its assault is incapable of impeding the onward march of genetics in the U.S.S.R.

The fact that Academician Lysenko is director of the Institute of Genetics of the Academy of Sciences does not mean that other schools of Soviet geneticists are in any way hampered in their work. It would be wrong to deny that Academician Lysenko has influenced the development of genetics in the U.S.S.R., but this influence has been exerted in open debate between proponents of different scientific views and principles and not by political pressure, as described by Professor Sax.

The way in which science has developed in the U.S.S.R. combines centralized planning with the creative endeavor of individual, decentralized laboratories. The present war has witnessed a tremendous development of science in our country, especially pure science. In the course of just over a year (up to December, 1944) four new academies were established—the Academy of Medical Sciences, the Academy of Pedagogical Sciences, the Uzbek Academy of Sciences and the Armenian Academy of Sciences. Science is also well developed in our universities and other schools of learning.

From this outline, it can be seen that science can be free in a centralized socialist state, which Dr. Sax wrongly calls totalitarian. Professor Sax does not understand the essence of the Soviet conception of the bonds between pure science, its application and philosophy, according to which the materialist philosophy of nature can only develop on the basis of the development of the various sciences; he therefore incorrectly states that in our country "science must conform to political philosophy." Because of this lack of understanding he failed to realize that the statements of Lysenko concerning the supposed refutation of Mendel's laws on the basis of dialectic materialism have little in common with the serious development of philosophy in the Soviet Union. Dialectic materialism is based on real facts and never denies them. Therefore the philosophy of dialectic materialism, when truly understood, can not possibly hinder the development of genetics. This philosophy, on the contrary, is a powerful weapon in the hands of the scientist who has thoroughly mastered it, and one which helps him to solve the most complicated theoretical problems.

The quotation of Professor Sax from "Science and Society" reflects a mistaken view on the part of the editors of this journal. In his speech made in 1939, Academician Mitin expressed entirely his own views, and not in any way the viewpoint of the Soviet Government.

The undoubted strength and vitality of the Soviet Government is due to that of its founder, Lenin, who himself had a long training in science and the philosophy of dialectic materialism, and of its present leader, Stalin, who has continued and strengthened the scientific and philosophical basis of our State. The well-known achievements of the Soviet Union in all branches of knowledge are due entirely to the attention which the Soviet Government has paid to the development of all forms of scholarship. The progress of science and culture was a deciding factor in the victories of our armies over fascist Germany and her satellites, who had the industrial might of all Europe behind them.

Russian scientists have a high opinion of the scientists of America and the great contribution they have made to world science. They respect the democratic principles of American society which Hitlerite reaction menaced in the same way as it menaced our own Soviet State principles—a higher form of democracy in so far as all State bodies are elected by the whole people in accordance with our democratic constitution. Together with American scientists we who are working in this field in Russia are building up a common, world-wide biology. We hope that this unfortunate misunderstanding of the basic ideas of our country, and of the path of development taken by Soviet science will be speedily dispelled, and that in the future the scientists of the two countries will progress together in an atmosphere of mutual understanding and comradeship.

ANTON R. ZHEBRAK
TIMIRIAZEV AGRICULTURAL ACADEMY,
MOSCOW, U.S.S.R.

AMYLASE INHIBITOR OF NAVY BEANS

SIMPLE aqueous extracts of ground navy beans contain a heat-labile fraction which retards the activity of pancreatic amylase. The influence of such extracts upon the digestion of soluble starch becomes apparent with decreasing pH, causing progressive magnifi-

cation of the unfavorable influence of the increased hydrogen ion concentration itself. For example, 10 cc of a centrifuged one per cent. aqueous extract of ground navy beans may be observed to reduce the digestion of 100 mg of soluble starch at pH 4.7 to 16 per cent. of the uninhibited digestion at neutrality, while in the absence of the inhibitor, at pH 4.7, the corresponding value was found to be about 60 per cent. of the uninhibited digestion at neutrality.

Similar observations may be made with preparations derived from simple aqueous extracts by precipitating the active fraction with alcohol after removing most of the inert proteins by precipitation at pH 4.0. One milligram of such a preparation may decrease the digestibility of 100 mg of soluble starch at pH 5 to about 75 per cent. of that of the control at the same pH. Increasingly larger proportional amounts of the retarding fraction further increase this interference.

With the fraction employed, antiamylolytic activity is retained following repeated reprecipitation with alcohol but is markedly decreased by boiling or by treatment with kaolin. The preparations used showed antitryptic[1] as well as antiamylolytic activity and were, in fact, considerably more active with regard to the former.

DONALD E. BOWMAN

DEPARTMENT OF BIOCHEMISTRY AND PHARMACOLOGY,
INDIANA UNIVERSITY SCHOOL OF MEDICINE,
INDIANAPOLIS

ON THE FORMATION OF ACETYLCHOLINE IN THE NERVE AXON

IN our recent paper published under this title in SCIENCE (Vol. 102, p. 250) an error occurred in the figures of the table. The correct figures for the amounts of acetylcholine formed per gram and hour in normal (n) and degenerated (d) sciatic nerve are: 48 hours after section of the sciatic in one experiment, 53.0 (n) and 51.0 (d); in a second 41.0 (n) and 33.0 (d); 72 hours after section in one experiment, 51.0 (n) and 29.0 (d), in another 52.0 (n) and 17.0 (d).

DAVID NACHMANSOHN
HEDDA M. JOHN

DEPARTMENT OF NEUROLOGY,
COLLEGE OF PHYSICIANS AND SURGEONS,
COLUMBIA UNIVERSITY

SCIENTIFIC BOOKS

OPTICAL ENGINEERING

Fundamentals of Optical Engineering. By DONALD H. JACOBS. 487 pp. 343 illustrations. McGraw-Hill Book Company. 1943. $5.00.

THIS text was prepared for use in the training of technical personnel for optical development and manufacturing. The treatment is an elementary one throughout, and no attempt at mathematical derivation is made. The mathematical knowledge required is limited to elementary trigonometry and algebra. Problems and bibliography are included for each chapter, and there is a complete index; drawings and photographs are clear and well reproduced. Such a book was needed in this country, and Dr. Jacobs's text has undoubtedly proven useful; a fourth printing recently appeared. The literature on optical instruments and design is quite limited in this country—nothing comparable to Merté, Richter and von Rohr, Conrady or Twyman has been published on American practices. The principles and methods of lens design are not general subjects in engineering schools, and optical instruction has lagged behind that in other branches of modern technology.

The construction of an optical instrument involves lens design, mounting design and production techniques in both optical and mechanical shops. A useful text must therefore combine a theoretical with a practical approach; Dr. Jacobs treats the optical aspects quite thoroughly. Subject headings include: the fundamental properties of lenses, stops and prisms; the photometric properties of images; low-reflectance coats; optical glass and its defects. Within military security regulations he discusses the functioning of the optical and mechanical elements of military telescopes, periscopes, gunsights and range finders. There is also a description and classification of standard camera objectives, which includes some data on the useful field and speed of commercially available types. The section on mechanical design is less systematic. There is an elementary description of machine shop operations with notes on bearings, gears, electric motors and photoelectric cells. No description of the principles of the operation of optical grinding, generating or polishing machinery is included, although these are peculiar to the optical industry, and no modern book on standard techniques in this country is available. It is to be hoped that a future edition might be expanded to include optical working and testing processes for lenses and flats.

The sections on the properties of lenses and on the actual methods used in the design of optical systems are naturally the most valuable, as well as the most difficult for the student. The process of ray tracing is described fully, with check computation methods, although no formulae are given for sagittal or skew rays. Tracing rays is a laborious and time-consuming

[1] D. E. Bowman, *Proc. Soc. Exp. Biol. and Med.*, 57: 139, 1944.

process; trial-and-error methods are inefficient in lens design. Dr. Jacobs uses the methods of theoretical computation of the aberrations, surface by surface, described by Conrady, whose notation he also adopts. The possible usefulness of the method involving the aberrations of the lens as a whole might be stressed. The notation and formulae given, for example, by Gardner in "Scientific Papers of the Bureau of Standards, No. 550," are excellent and give a deeper insight into the properties of complex systems; furthermore they permit the isolation of trial solutions quickly. A further possible criticism may be directed against the suggested computation of longitudinal aberrations; in camera lenses the lateral aberration on the focal plane is of practical importance while in telescopic systems the angular aberration is the most useful quantity.

The ideas involved and the general approach to a lens-design problem, together with the differential correction of a preliminary design, are treated in some detail. The student should obtain sufficient insight to design aplanatic objectives, standard eyepieces and simple telescopes. The final chapter discusses optical tolerances and gives methods for estimating quantitatively the permissible aberrations in a lens system. The text will undoubtedly prove useful to physicists as well as to technologists and helps to fill a gap in the literature on modern optics.

JESSE L. GREENSTEIN

YERKES OBSERVATORY,
WILLIAMS BAY, WIS.

SEROLOGICAL REACTIONS

The Specificity of Serological Reactions. By KARL LANDSTEINER, M.D. Revised edition. Cambridge 38, Mass.: Harvard University Press. $5.00.

WHEN the reviewer compares the first with the revised edition of this work, he is impressed with the extent to which the author has gone in rewriting and extending the discussions of the material comprising the first edition as well as his success in bringing each subject up to date as of 1944. The first edition contained 178 pages, including the index, as compared with 310 pages in the revised edition. The increased number of pages is due in part to the addition of new material throughout the book and the development of two new chapters, one of 35 pages entitled "Antigen-Antibody Reactions" and the second of 19 pages entitled "Molecular Structure and Intermolecular Forces." In all there are eight chapters in the revised edition.

In the previous edition the first chapter contained only a brief discussion of antibodies and of "specificity" as related to serological reactions. This has been extended to include a discussion of the "Principal Immunological Phenomena and Nomenclature." The reader is supplied with simple definitions of various immunological terms. Reference is also made to methods of immunization and to the significant steps that have occurred in the development of immunology.

The second chapter is entitled "The Serological Specificity of Proteins" and has been enlarged from 34 to 62 pages. The author has expanded his discussion of the work of Dean and Webb on optimal proportions and of Heidelberger and Kendall's work on estimation of the amount of antibody in serum by nitrogen analysis. In both the first and the revised edition the author speaks of the rabbit as being a rodent. This concept leads him to say that "from this it may be understood why rabbit immune sera are very useful for revealing dissimilarities in the proteins of other rodents, . . ." This is rather surprising since the zoologists have for many years classified rabbits as belonging to an entirely different order called Lagomorpha.

Further on in this chapter he discusses some of the newer factors determining specificity and says that "one can not safely offer an opinion concerning the specific groups of protein (determinants) as long as it is not known what the maximal size of such a determinant can be." The author seems to feel that the view advanced by Obermayer and Pick that aromatic groups have prominent significance is probably incorrect. He feels, however, that one can not flatly deny that aromatic groups may be of greater importance than others for the specificity of protein reactions.

Chapter 3 is entitled "Cell Antigens," and in size has been increased by nine pages. The author stresses in both editions the two kinds of specificity—the one observed in proteins and the other observed in cells. He has added numerous references to his discussion of heterophile antigens and their behavior as well as to the specificity of the Wassermann reaction, and suggests the inadvisability of the use of the term "antigen" in reference to the use of the Wassermann substance. He also adds a section of new material entitled "Antigenicity of Phosphatides, Sterols, Starch et cetera."

The title of Chapter 4 has been changed from "The Specificity of Antibodies" to "The Nature and Specificity of Antibodies" in the revised edition. The chapter has been expanded from 14 to 20 pages. The first two pages of the chapter are largely rewritten. He has added a discussion of the work of Kidd and Friedewald and of Durham-Reynolds on natural antibodies, especially those acting upon material derived from the same individual and other members of the same species. The section on immune antibodies is completely rewritten. The subject is discussed under

the following headings: Physico-Chemical Properties, Purification Methods, Antibodies and Normal Globulins, Alteration of Antibodies, Plurality of Antibodies in Sera, Formation of Antibodies and the Theories of Antibody Formation.

Chapter 5 is devoted to a discussion of artificial conjugated antigens and serological reactions with simple chemical compounds. Most of the old material has been rewritten and much new material added. He calls attention to the observations of Haurowitz that strongly basic groups may be as effective as acid groups in directing specificity. The author has introduced new material under two new headings, one entitled "Carbohydrate-Azoproteins," and a second entitled "Pharmacologically Active Substances, Hormones." In connection with this the author discusses the attempts and failures to produce antibodies to strychnine and the success achieved in producing antibodies to thyroxine.

The title for Chapter 6 has been changed from "Chemical Investigations in Specific Cell Substances, Carbohydrates, Lipoids" to "Chemical Investigations on Non-Protein Cell Substances." In the revised edition one topic heading entitled "Serum Reactions with Phosphates and Sterols" has been deleted and four new topics added. These latter deal with "Complex Bacterial Antigens," "A Polypeptide-Like Haptene," "Preparation of Artificial Antigens Using Bacterial Proteins" and "Blood Group Substances," respectively. A few of the important things discussed by the author under these new headings are many recent findings relative to antigenic substances in both Gram-negative and Gram-positive bacteria; the polypeptide-like substance from *B. anthracis;* the new antigen prepared by combining the typhoid protein with the Shiga polysaccharide; and the precipitation of the blood group substance by antisera specific for the polysaccharides of Pneumococcus XIV.

Chapter 7 is entitled "Antigen-Antibody Reactions." In this new chapter the author discusses toxin neutralization, various aspects of the precipitin reaction, the mode of combination of antigen with antibody and serological specificity. In regard to agglutination and precipitation, the author concludes that it may be that both specific and non-specific forces may operate in the second stage of the reactions. As to the mode of combination of antigens with antibodies, he says that while there is data that warrants the correlation of serological specificity and chemical structure, yet "no finished theory of antibody reactions has yet been attained that is comparable to those that cover and make it possible to formulate the reactions of organic chemistry." While he frankly states that the present nature of the forces involved in serum reactions is still open to discussion, he says that "it is supposed that the union between antigen and antibody is brought about chiefly through electrically charged acid or basic groups, van der Waals forces and interaction between polar groups (or polar groups and ions) in which as Pauling emphasizes, hydrogen binding presumably plays an important part."

The final chapter of the book is contributed by Pauling and is entitled "Molecular Structure and Intermolecular Forces." Early in the chapter the author states that "it is, indeed, probable that the high specificity which often characterizes physiological activity is in most cases specificity of intermolecular interaction rather than primarily of chemical reaction with the rupture and formation of strong bonds." He discusses the structure of molecules, electronic van der Waals attraction, hydrogen bonds, and the interaction of electrically charged groups in proteins and their relation to serological reactions. It is a well-written chapter and throws light upon many statements made in the preceding chapters.

The reviewer feels that the book is well written and is indeed a classic in the field of immunology. It should be regarded as a "must" book for all who are both interested in the subject and who possess an adequate scientific background.

NOBLE P. SHERWOOD

UNIVERSITY OF KANSAS

THE ALGAE

Structure and Reproduction of the Algae. By FELIX E. FRITSCH. Vol. 2 (Phaeophyceae, Rhodophyceae, Myxophyceae). xiv + 939 pp. Frontispiece. 336 text figs. 2 maps. Cambridge: University Press. 1945.

PROFESSOR FRITSCH has undertaken the immense task of bringing together all that is known of the morphology and reproduction of the great plant group of Algae. Modern developments in this field are so extensive that it probably will not be possible for one man to accomplish this again. Only once before has it been successfully attempted, when Oltmanns[1] brought together a summary of all that was known about algae except their detailed taxonomy. Fritsch's two volumes are alike in treatment and constitute an advanced reference work. The amount of material reviewed is huge, and documented in detail; it is clear that every effort was made to include all significant work. After a Foreword the author analyzes the three great groups not covered in the first volume. These are dealt with in the same meticulous fashion which characterized the treatment of the Chlorophyceae and other groups covered earlier.[2] For each of the three classes there are several pages of general

[1] "Morphologie u. Biologie d. Algen," 1904–05, edit. 2, 1922–23.

[2] Vol. 1, 1935; SCIENCE, 83: p. 437, 1936.

information regarding cell structure, vegetative organization, food reserves and reproduction, followed by detailed descriptions of the special morphology and reproduction of each family.

It evidently was not the author's object to stress more than morphology and reproduction; taxonomy appears only so far as is necessary to give orderly presentation, and ecology, physiology and utilization are but incidentally involved. Fritsch has managed very well to bring together the immense new literature, avoiding that which is unsound or superficial, while retaining that part of the old material which has never been superseded.

The Foreword presents a brief introduction to seaweeds through their ecology and distribution. The ranges offered for some of the examples selected seem misleading; for instance, on the maps the southern boundary for the Agareae on the American coast is set on Labrador, though these plants are well known to occur in northern Massachusetts, and for the Laminariales in general it is set on Nova Scotia, though these plants are common off southern Masachusetts. The folding maps are inconvenient; if the data had been divided and small maps used as text figures they would have been more effective.

The morphology and reproduction of the Phaeophyceae are treated for each group in order, with a section summarizing our knowledge of the life histories. The works of Sauvageau, Svedelius and Kylin have contributed most to the expansion of the account over earlier compilations. The author naturally develops the discussion in line with his views on the primitive heterostichous state of these plants, a conception which he has enlarged upon in several recent papers. He stresses the importance of vegetative structure rather than the degree of reproductive differentiation. This produces a change in the sequence of treatment of the Orders, and causes the merging of Punctariales and Dictyosiphonales as climax families in the ectocarpalean series. Emphasizing the type of growing point he associates the Sphacelariales, Dictyotales and Fucales with increasing departure from the single apical growth initial.

The Rhodophyceae are divided in the usual fashion into Bangioideae and Florideae. In the first subclass the Porphyridiaceae is accepted, and enlarged to include such filamentous genera as *Asterocytis* and *Goniotrichum*. The Florideae are considered first from the general morphological standpoint, which calls for an immense amount of detail. The heterostichous habit is again a basis for interpretation and is only considered lacking in the Ceramiales. There are sections on symbiosis, special cell contents and such features. Reproduction is then discussed in another review of the families, using a relatively few types thoroughly analyzed in each. A large proportion of this material is recent, based on the work of Svedelius, Kylin and other contemporaries; in general the classification developed by Kylin is followed.

The Myxophyceae are largely covered in general sections, as the low degree of plant organization does not require a detailed systematic approach. Perhaps because of this, this section, thorough though it is, seems rather more attractive to a general botanical reader than the very detailed treatment of the Rhodophyceae.

The two volumes of this work by Fritsch are of about equal thickness, because of slightly thinner paper and boards used for the second, though it is about 150 pages longer. The cloth, boards and binding seem too light for a work of this bulk and potential length of service. The quality of the paper is commendable under war-time circumstances, though its uneven color betrays the difficulties under which it was produced. The 336 groups of pictures give a wealth of illustration greater than has been attempted in a work of this kind; most of them have not been used before in a text-book, and have been taken from the most recent research publications. Reproduction of the drawings is very good, and the halftone cuts were evidently most carefully prepared by the engraver, though the character of the paper has prevented the end results from being as good as in the first volume.

In summary, we have now for the first time in English a comprehensive account of algal morphology, including reproduction, adequately related to physiology, ecology and presumed evolutionary trends, in an excellent and convenient form. Its completion represents a very great accomplishment, and the long period through which it will remain a standard reference justifies the labor spent upon it.

WILLIAM RANDOLPH TAYLOR
UNIVERSITY OF MICHIGAN

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